

Hanford Corrosion Testing at CC Technologies

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High-Level Waste Tank Integrity Workshop
May 2008



Overview and Background

■ Objective

- Determine propensity for corrosion (pitting) and SCC in waste simulants

■ Considering several different chemistries

- AN107 (high nitrate 3.4 M, high nitrite 1.2 M)
- AN102 (simulated as AN107 with 2 x chloride)
- AY102-PIL (high carbonate 1 M)
- AP101-TSC (high nitrate 2.13 M, high nitrite 0.98 M)
- AY101-PSC (high nitrate 1.33 M, low nitrite 0.2 M)
- AP105-PSC (high nitrate 3.58 M, low nitrite 0.27 M)
- SY103-PIL (high nitrite 2.91 M, high nitrate 1.97, bounding chloride 0.5 M)
- AW105-PIL (low nitrite 0.12, low nitrate 0.42 M, bounding fluoride 0.58 M)

Summary of Findings To Date

■ Approach

- Cyclic potentiodynamic polarization (CPP), open circuit (OCP) and potentiostatic tests to investigate electrochemical behavior
- Slow Strain Rate Tests (SSRT) and Crack Growth Rate (CGR) tests using Compact Tension (CT) to investigate mechanical behavior

■ General results

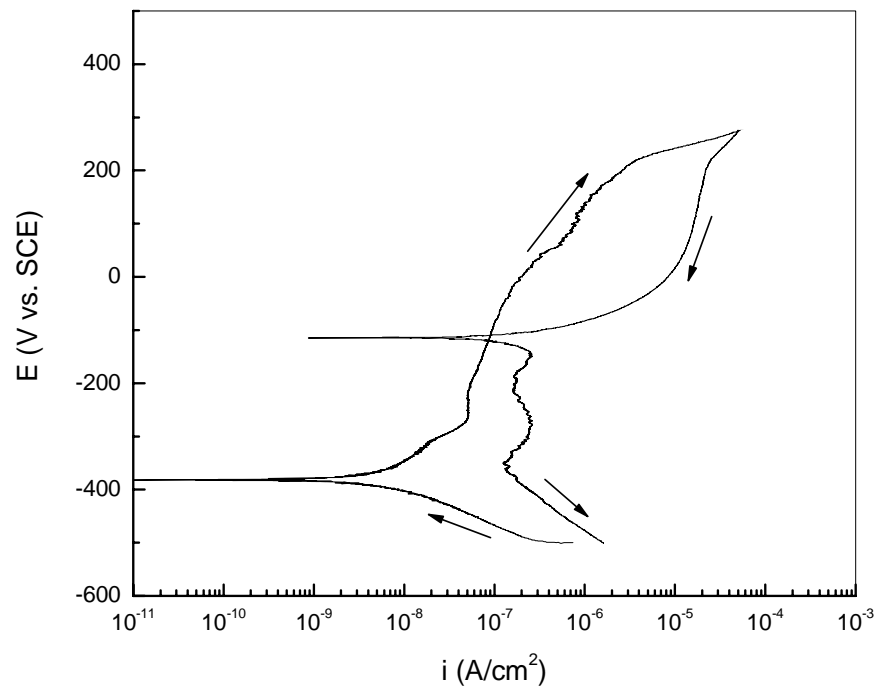
- In general, simulants relatively benign with respect to SCC at free corrosion potential
- Some examples of pitting and SCC, but only at applied potentials that are not likely to be observed in service
- Nitrite appears to act as an inhibitor
- Some interfacial corrosion observed in select tests at elevated temperatures

Experimental OCP / CPP

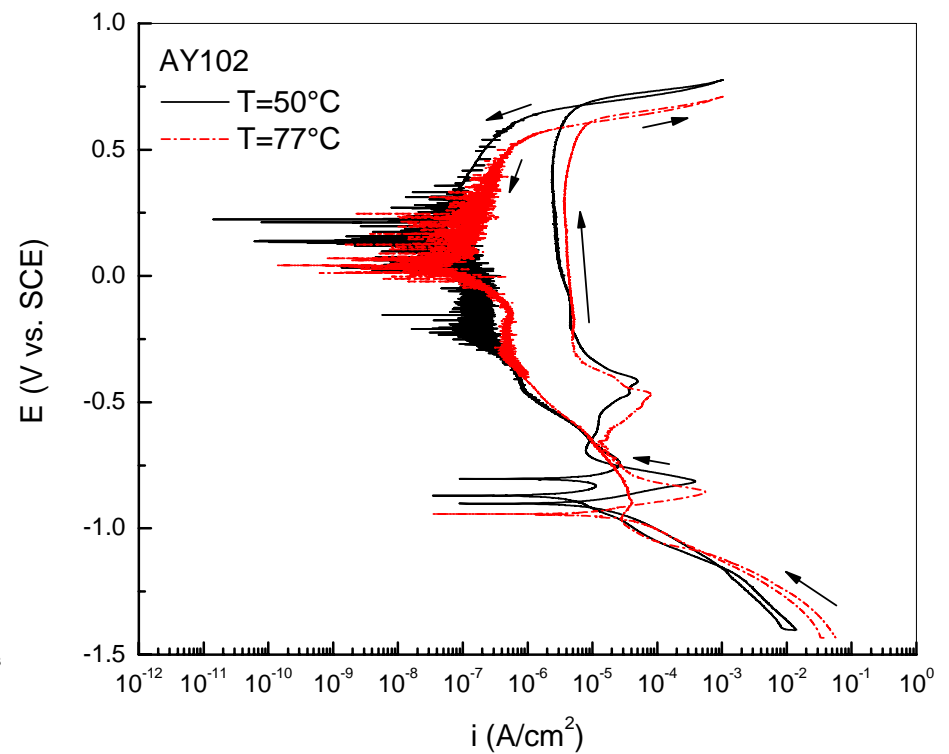
- Majority of samples fully immersed in simulant, limited cases used partial immersion
- Majority of samples continuously purged with nitrogen, limited cases quiescent (open to air) or gas (N_2 , Ar, zero air) purged;
- Room temperature, 50°C or 77°C;
- CPP: 0.17 mV/s; -0.1 V vs. OCP to $E=1$ V vs. SCE or $i=1$ mA/cm²

CPP of AN107 and AY102

- AN107 (high nitrate and nitrite)
- Hysteresis loop and pitting observed

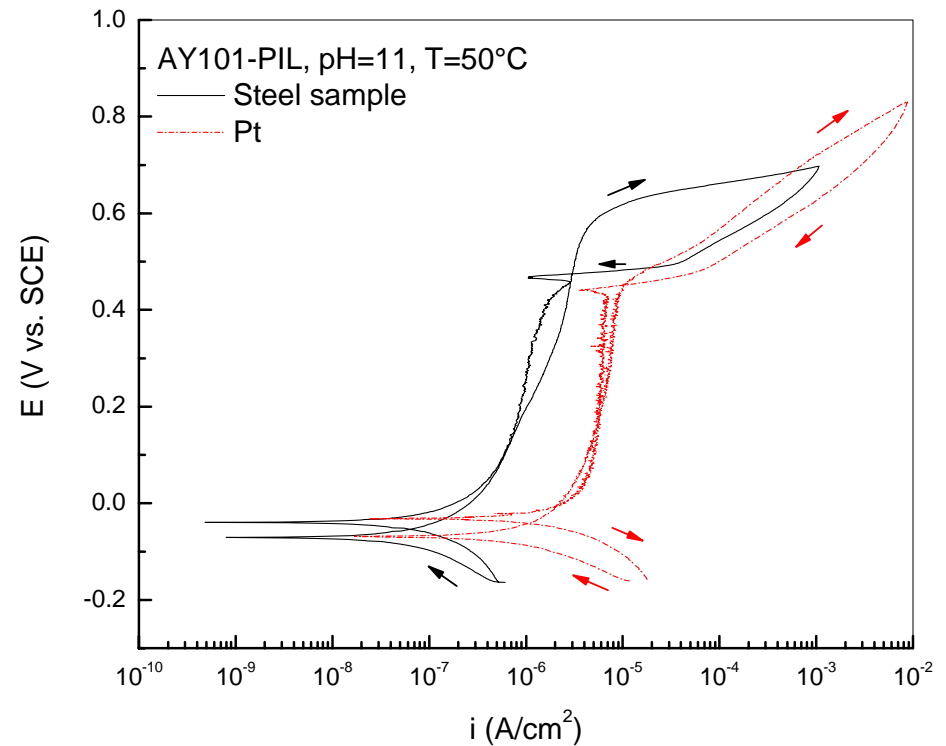
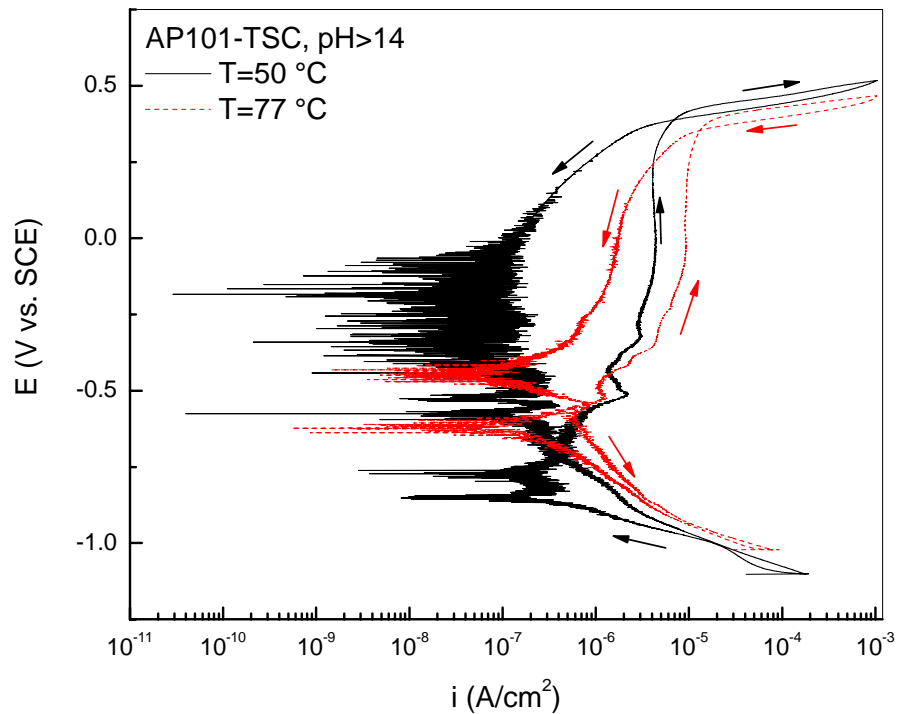


- AY102-PIL (high carbonate)
- Active-passive transition

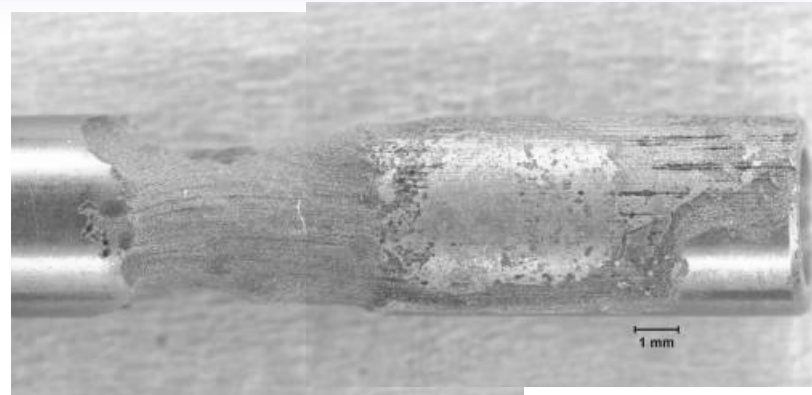
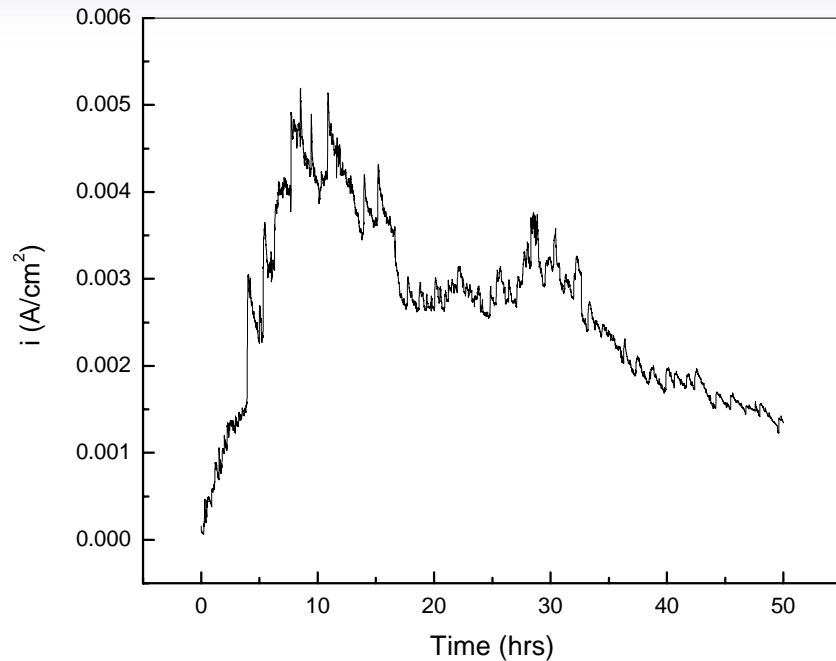


CPP of AP101 and AY101

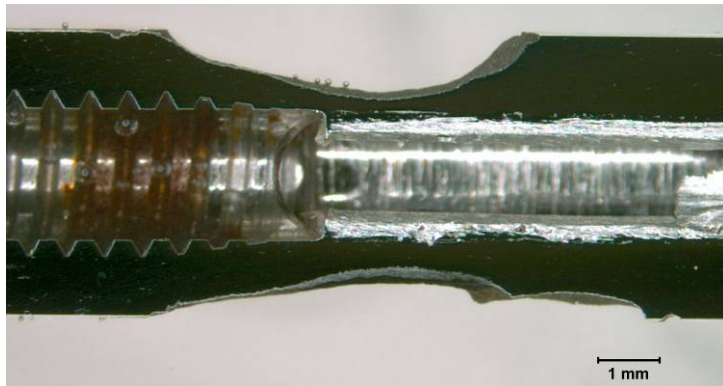
- AP101-TSC (high nitrate and nitrite)
- Negative hysteresis loop and no pitting noted
- AY101-PIL (high nitrate, low nitrite)
- Oxidation of electro-active species noted



AP105-PSC: interface corrosion

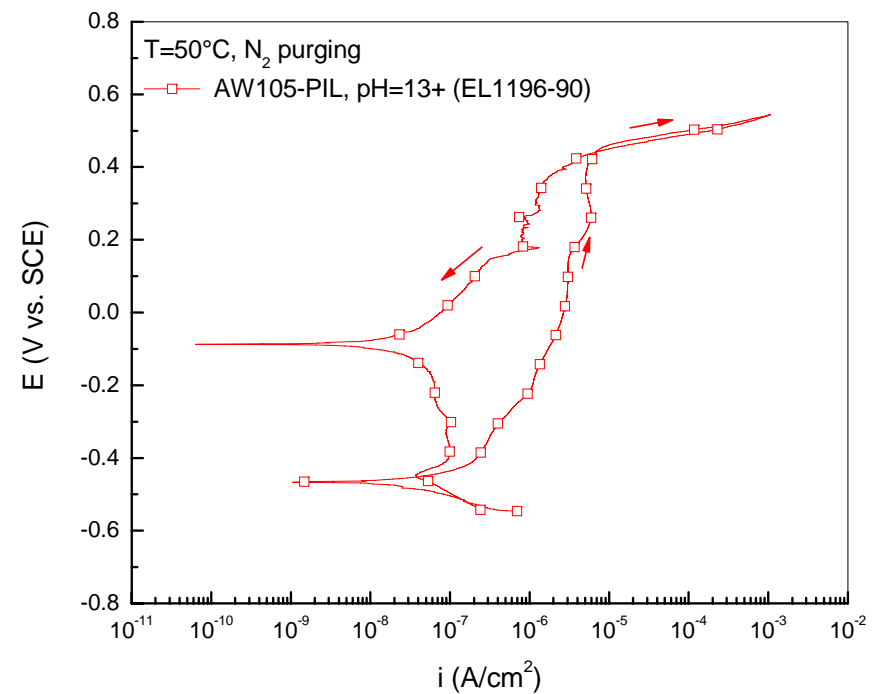
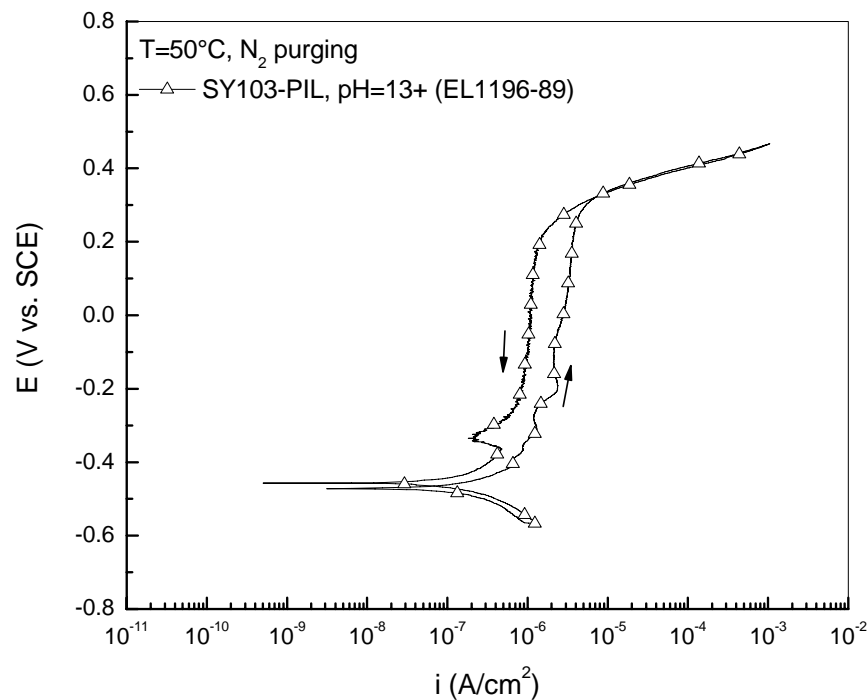


T=50°C



- Corrosion attack at the solution/vapor interface observed after 50 hours of potentiostatic hold at 0 mV vs. SCE (50°C)
- Investigation in progress

CPP of SY103-PIL and AW105-PIL



- No pitting corrosion was observed in either SY103 or AW105 simulants
- The nitrite and other inhibiting chemicals seemed to be able to provide inhibition against high chloride and fluoride levels ($\sim 0.5\text{M}$);

Conclusions from Electrochemical Testing

- Steel is susceptible to pitting corrosion in AN107 simulant but not in other simulants
- Active-passive transition noted on the CPP curve in AY102-PIL simulant. Carbonate induced SCC is likely near the transition region
- Interfacial corrosion observed in AP105-PSC test at elevated temperatures, investigation in progress.

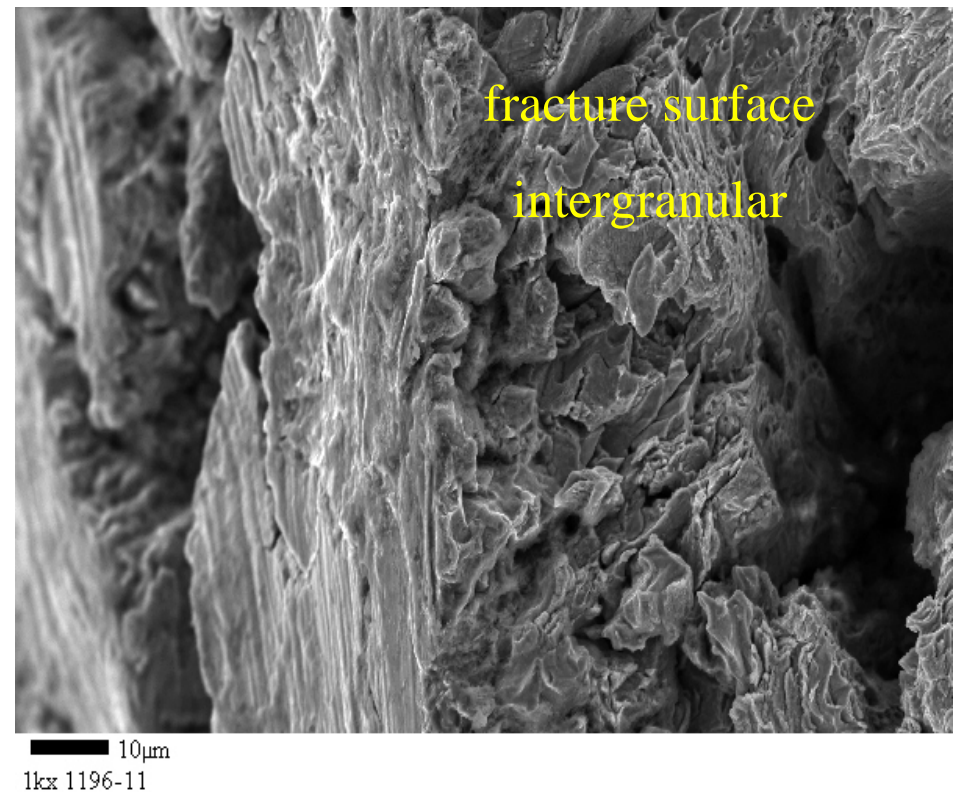
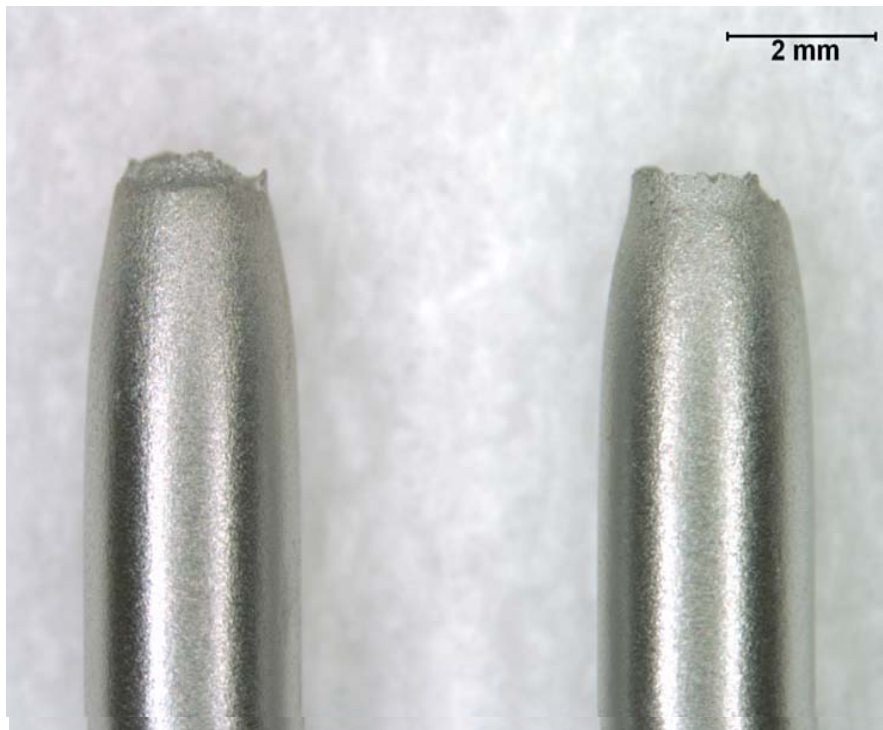
Basic SSRT Set-up

- Uniaxial tension test
- Specimen is immersed in test solution
- Potential controlled
- Temperature controlled
- Strain rate 10^{-6} /s
- Strain to failure
- Fracture surface examined visually/stereo/SEM



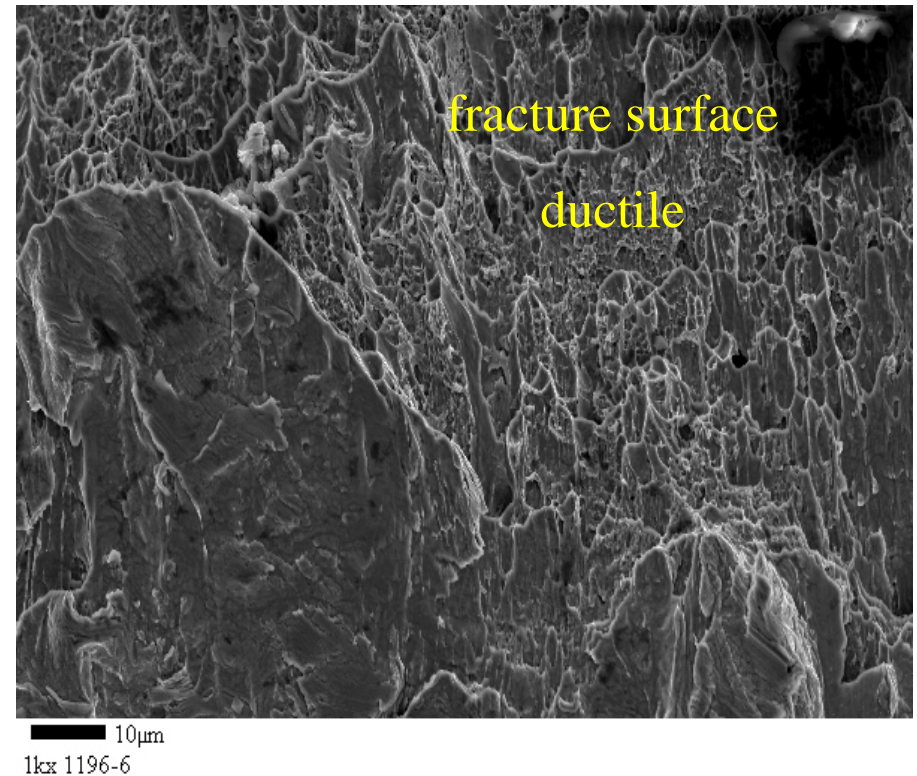
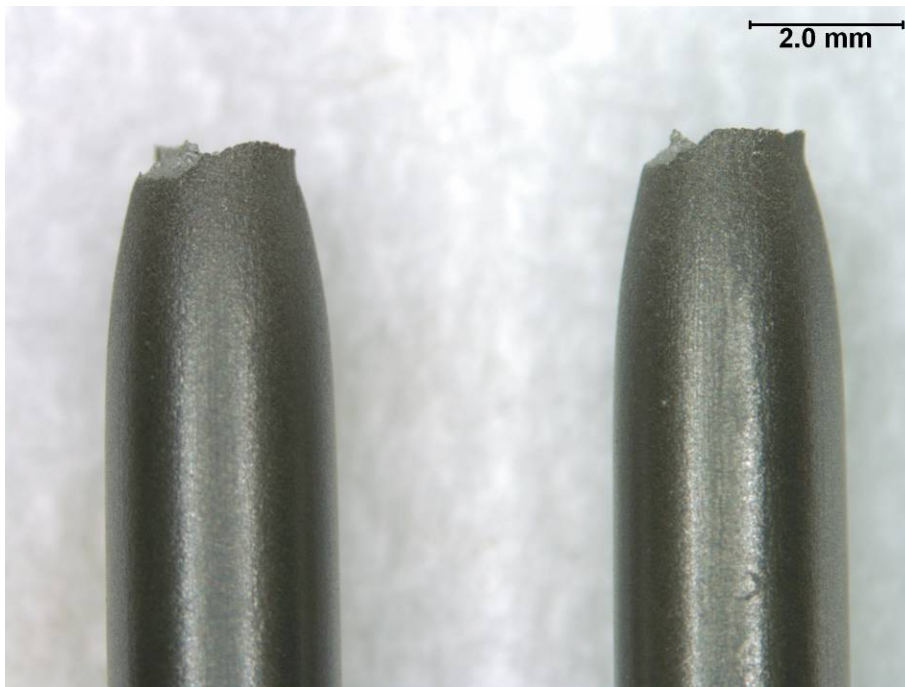
SSRT in AY102-PIL (carbonate)

- Test at OCP (-330 mV vs SCE)
- Comparable to service
- Test at -800 mV vs SCE
- Unlikely in service



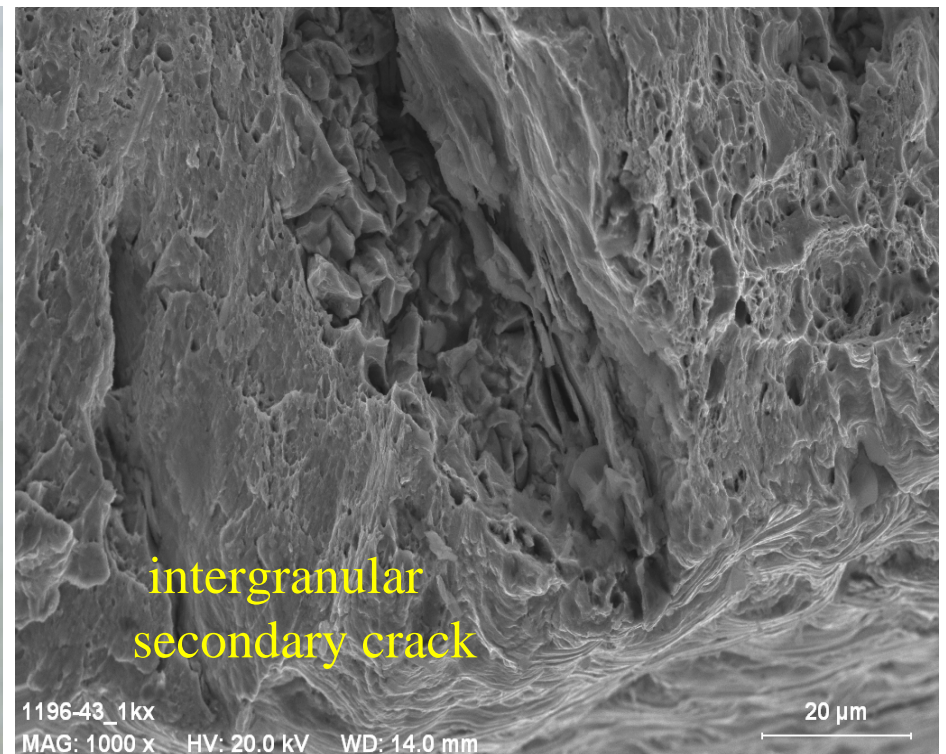
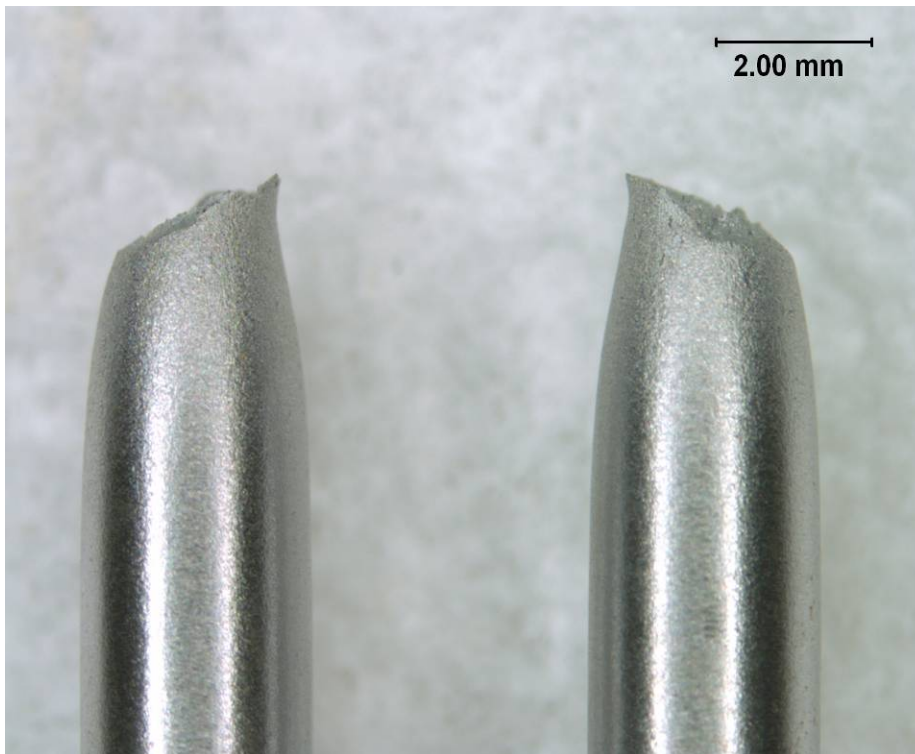
SSRT in AP101-TSC (nitrite/nitrate)

- Test at OCP (-448 mV vs SCE)
- Comparable to service
- Test at 0 mV vs SCE
- Unlikely in service



SSRT in AY101-PSC (nitrate)

- Test at OCP (-242 mV vs SCE)
- Comparable to service
- Test at 0 mV vs SCE
- Unlikely in service

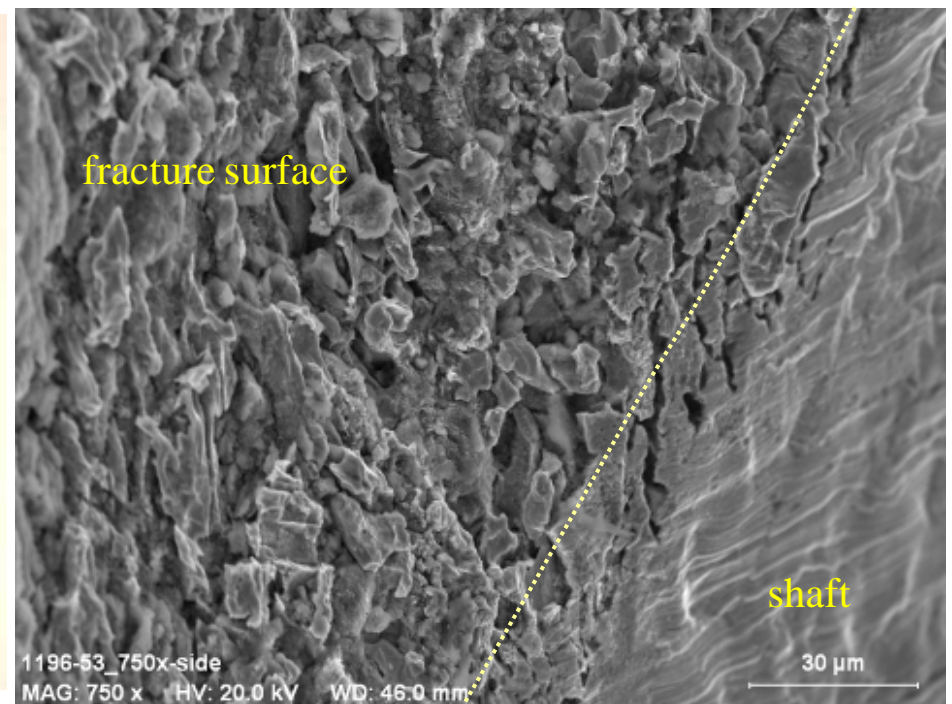


SSRT in AP105-PSC at 0 mV vs SCE

■ Stereo-microscopy of interface

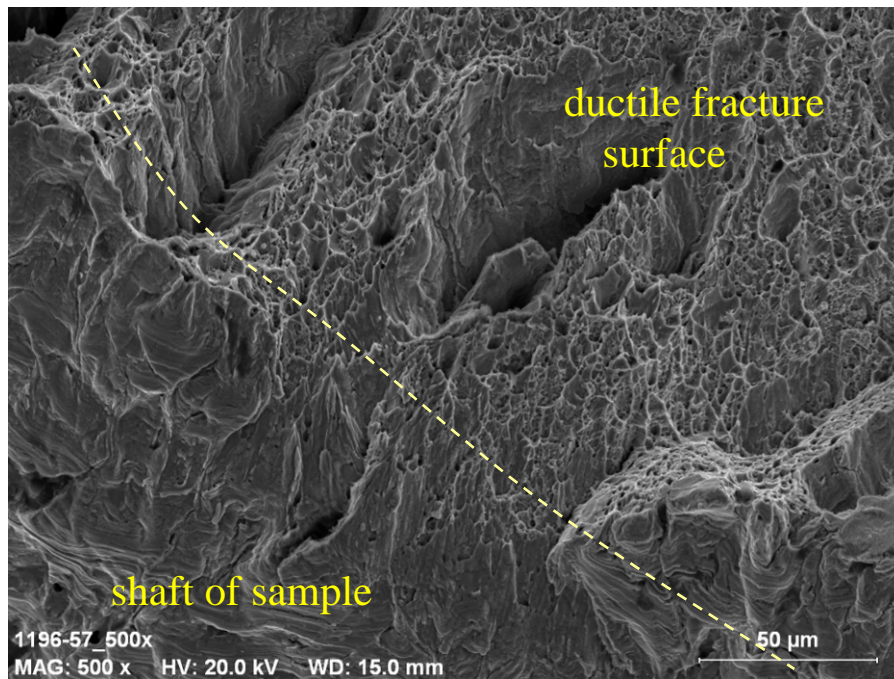


■ Fracture surface SEM exam

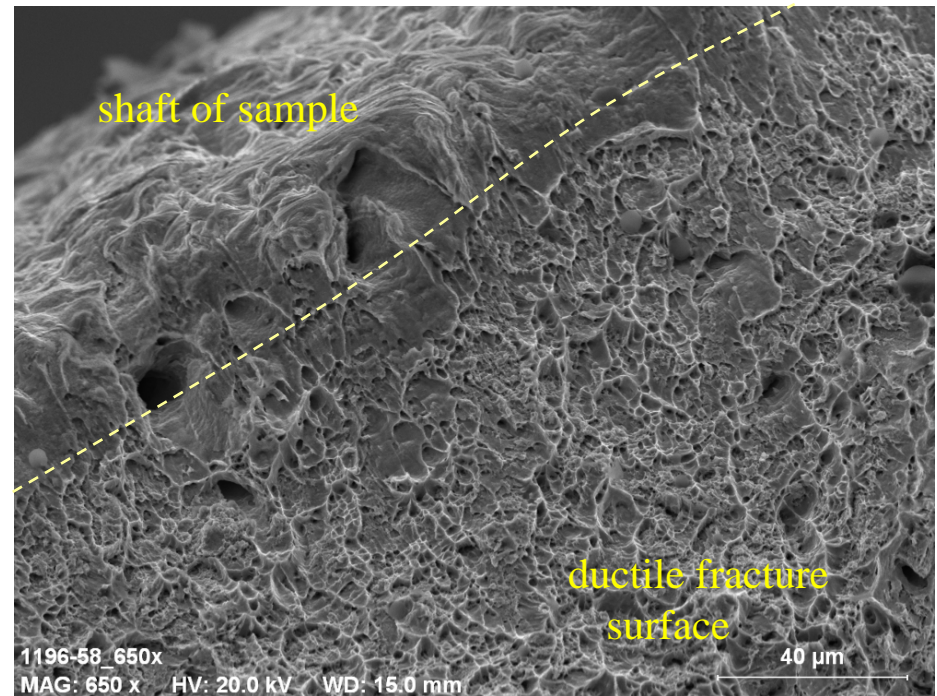


SSRT in SY103 and AW105

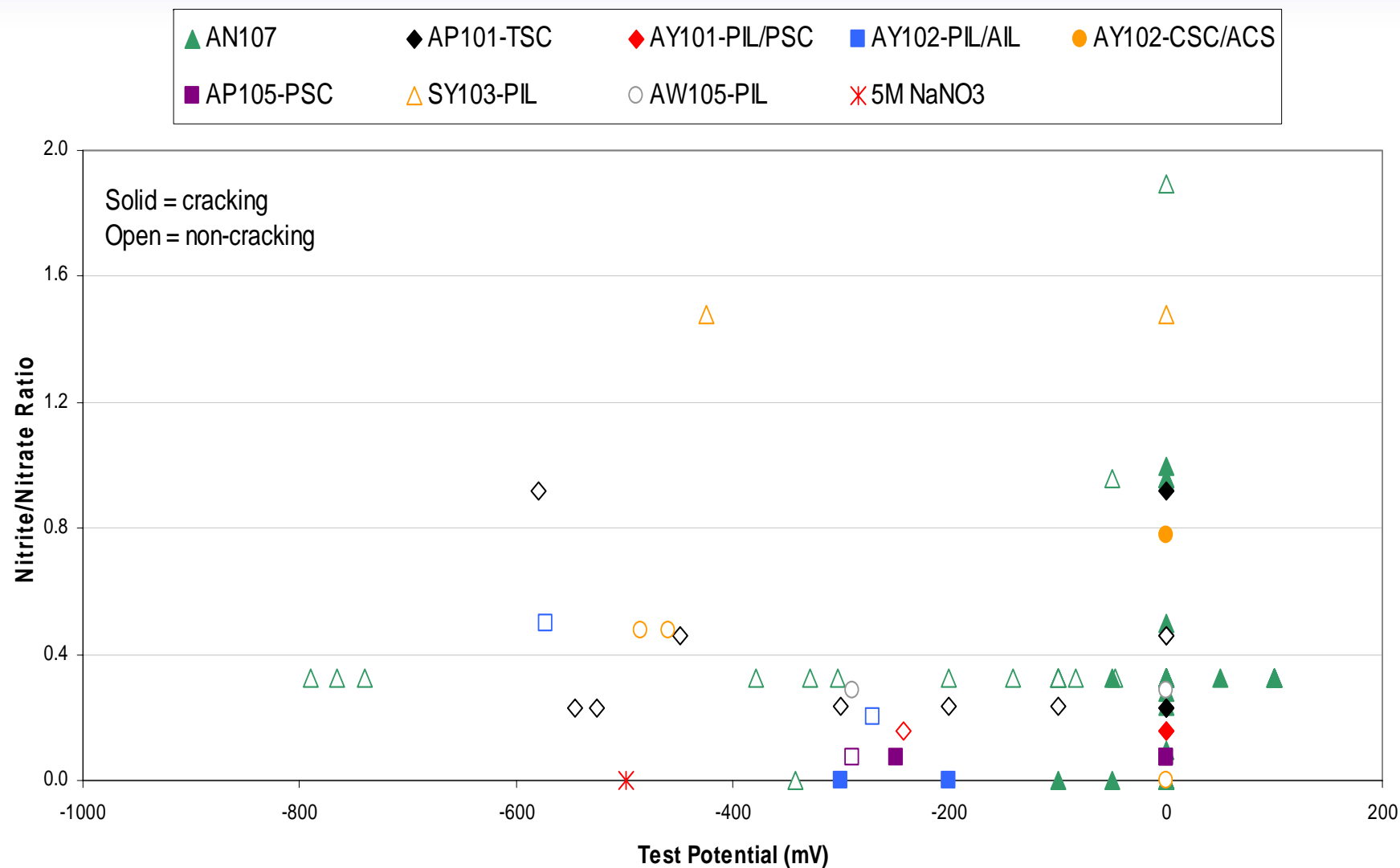
■ SY103 at 0 mV vs SCE



■ AW105 at 0 mV vs SCE



Plot of Nitrite/Nitrate Ratio vs Potential



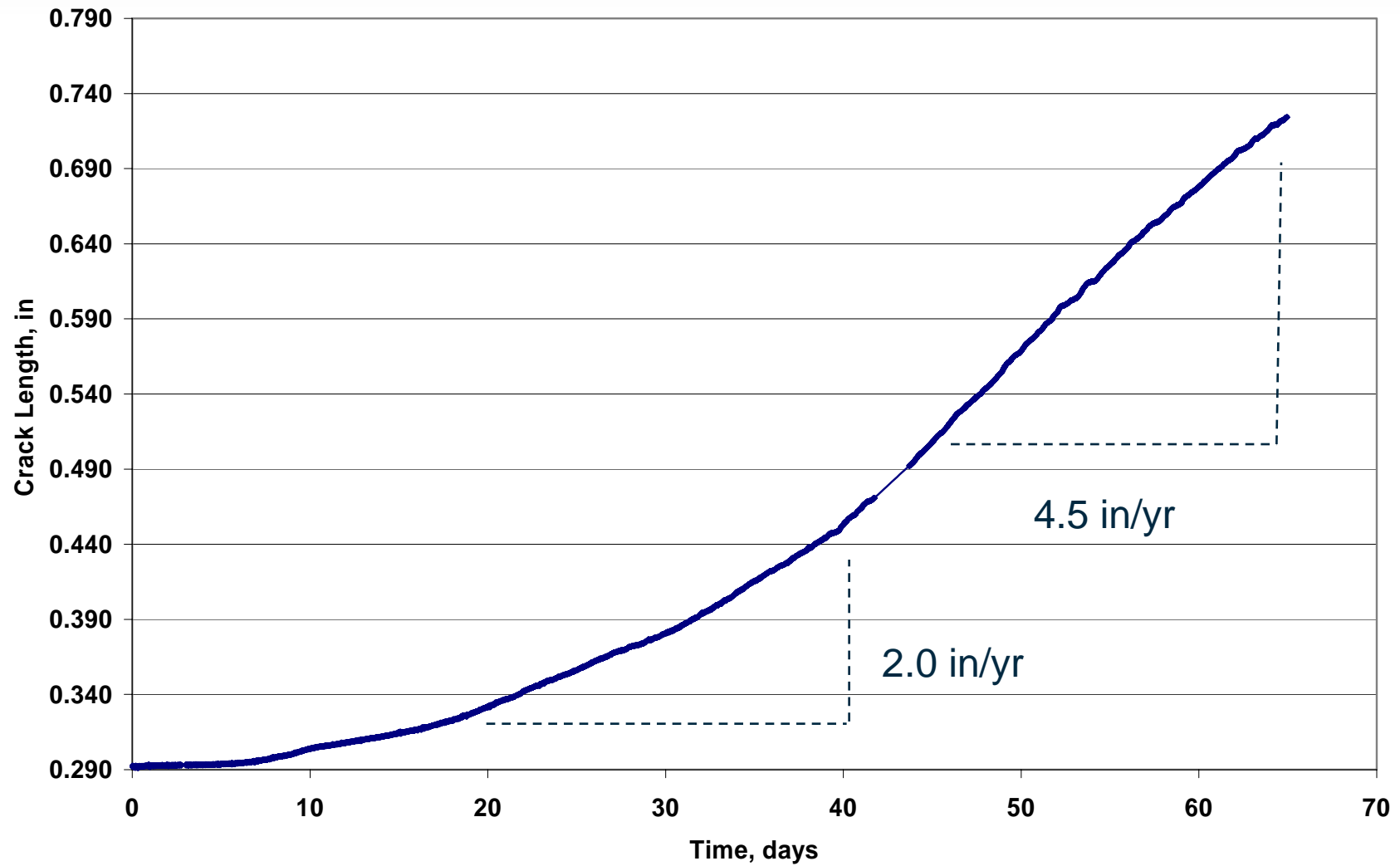
Conclusions from SSR Testing

- Simulants generally benign with respect to SCC at OCP
- SCC observed in nitrate base simulants when anodically polarized to 0 mV vs SCE
- SCC observed in carbonate based simulant at -800 mV vs SCE
- Previous nitrite/nitrate vs potential trend appears valid
- Interfacial corrosion observed in AP105-PSC test, investigation in progress.

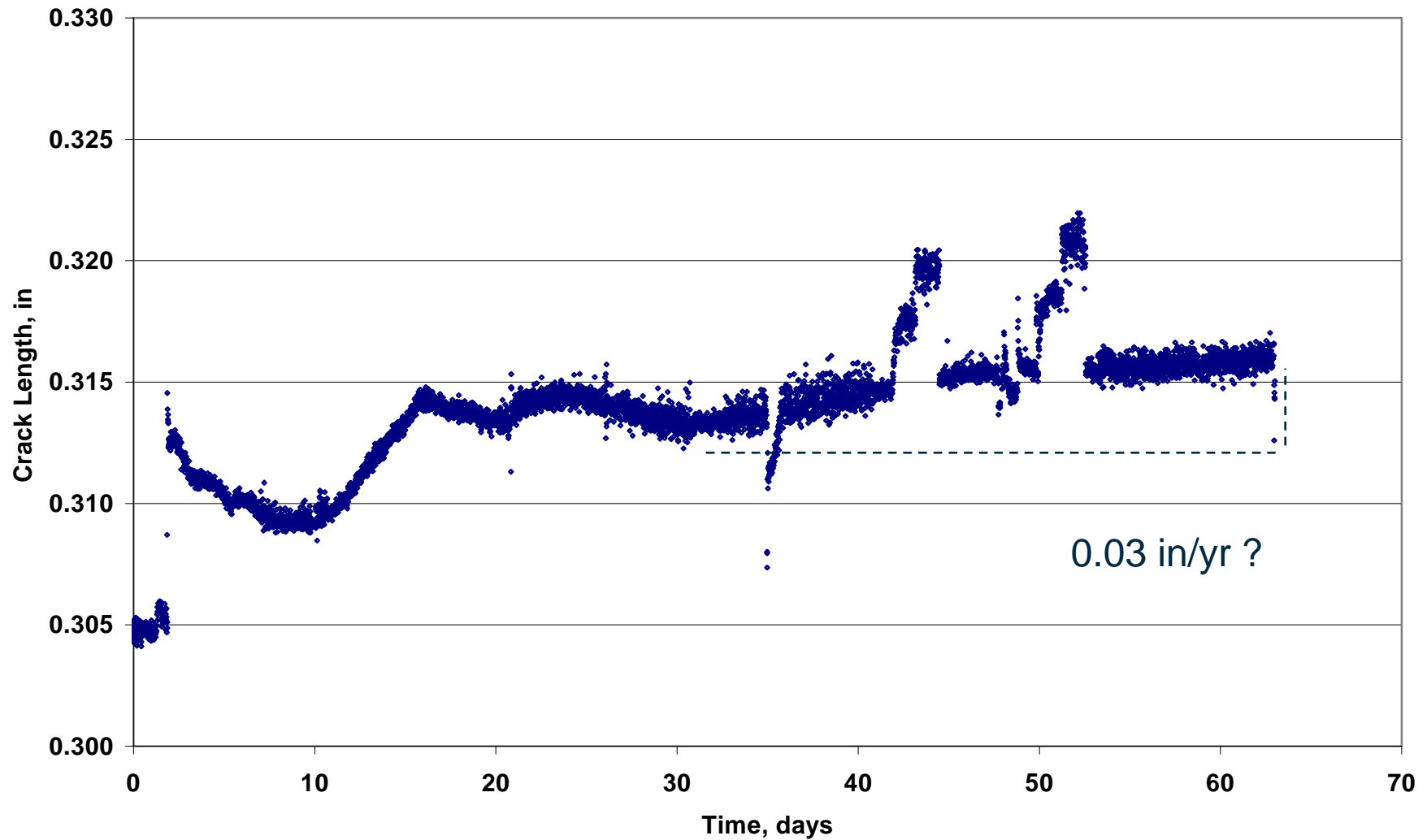
Dynamic-K Test Conditions

- 5M NaNO₃ solution
 - Monitor load and DCPD crack length
 - Loaded to ensure cracking
 - Hold for long term (4-6 months?) at constant displacement
 - In progress –significant cracking
- AY101-PSC simulant
 - Monitor load and DCPD crack length
 - Loaded to 45 ksi√in
 - Hold for long term (4-6 months?) at constant displacement
 - In progress – possible minor cracking

5M NaNO₃



AY101-PSC



Path Forward

- Testing in AP105 “Mixed” and “Evaporated” simulants
- Testing in AZ102 simulants
- Testing in various nitrite/nitrate/pH permutations
- Investigation of interfacial corrosion in AP105-PSC
- Completion of two K-Tests in progress